LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

M.Sc. DEGREE EXAMINATION – **PHYSICS**

SECOND SEMESTER – NOVEMBER 2016

PH 2816 - QUANTUM MECHANICS - I

Date: 14-11-2016 Dept. No. Max. : 100 Marks

Time: 01:00-04:00

SECTION –A

Answer **all** the questions. **(10 x 2 = 20 Marks)**

1. Show that $i\frac{d}{dx}$ is Hermitian.
2. If operators **A** and **B** are Hermitian, show that $i[\mathbf{A},\mathbf{B}]$ is Hermitian.
3. Show that the fundamental commutation relation $[x,p_x] = i\hbar$ remains unchanged under unitary transformation.
4. Show that Pauli matrices are trace *zero* and determinant *one* matrices.
5. Show that $\langle 0|a\, a^{\dagger}aa^{\dagger}|0\rangle = 1$, where a and $a^{\dagger}$ are the lowering and raising operators respectively.
6. Explain the general principle of the variational method.
7. Find the matrix representation of J_-, for $j=\frac{1}{2}$
8. If $j_1 = 1$ and $j_2 = 1$, what are the allowed values of resultant **J** and **m**?
9. Explain resonance scattering.
10. Distinguish between laboratory and center of mass coordinate system.

SECTION – B

Answer**any four** questions. **(4 x 7.5 = 30 Marks)**

11. Derive the equations of motion in the Heisenberg picture.
12. Explain the process of transformation of state vector and operator under unitary transformation.
13. Obtain the second order correction to the energy of a non-degenerate energy level using time-independent perturbation theory.
14. Using Bra and Ket notation, obtain the eigenvalue spectrum of J^2 and J_z.
15. Show that exp(ikz) can be represented as the sum of an incoming and outgoing spherical wave.
16. Show that (i) operators having common set of eigenfunctions commute.
    (ii) Commuting operators have a common set of eigenfunctions.

SECTION – C

Answer **any four** questions**.** **(4 x 12.5 = 50 Marks)**

17. With necessary theory, explain quantum mechanical tunneling.
18. Solve for the eigenvalues of the harmonic oscillator using the Heisenberg matrix method.
19. Discuss stark effect with reference to n=2 state of the hydrogen atom.
20. Obtain the C.G. coefficients for addition of angular momenta for $j_1=1/2$ and $j_2=1/2$
21. For scattering by an attractive square well potential, derive a general expression for phase shifts.
22. Obtain the eigenvalues of the radial part of the hydrogen atom.

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